The Pattern of Change in U.S. Streamflow

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Climate Change and Water Resources
USACE-USGS Joint Meeting

31 May 2007

USGS

Warmer temperatures will lead to a more v
hydrological cycle and . . .

increased frequency of extreme rainfall

increased frequency and magnitude of

declining low streamflows.

overnmental Panel on Climate Change (IPCC) Assessments, 1995, 2001, 2007

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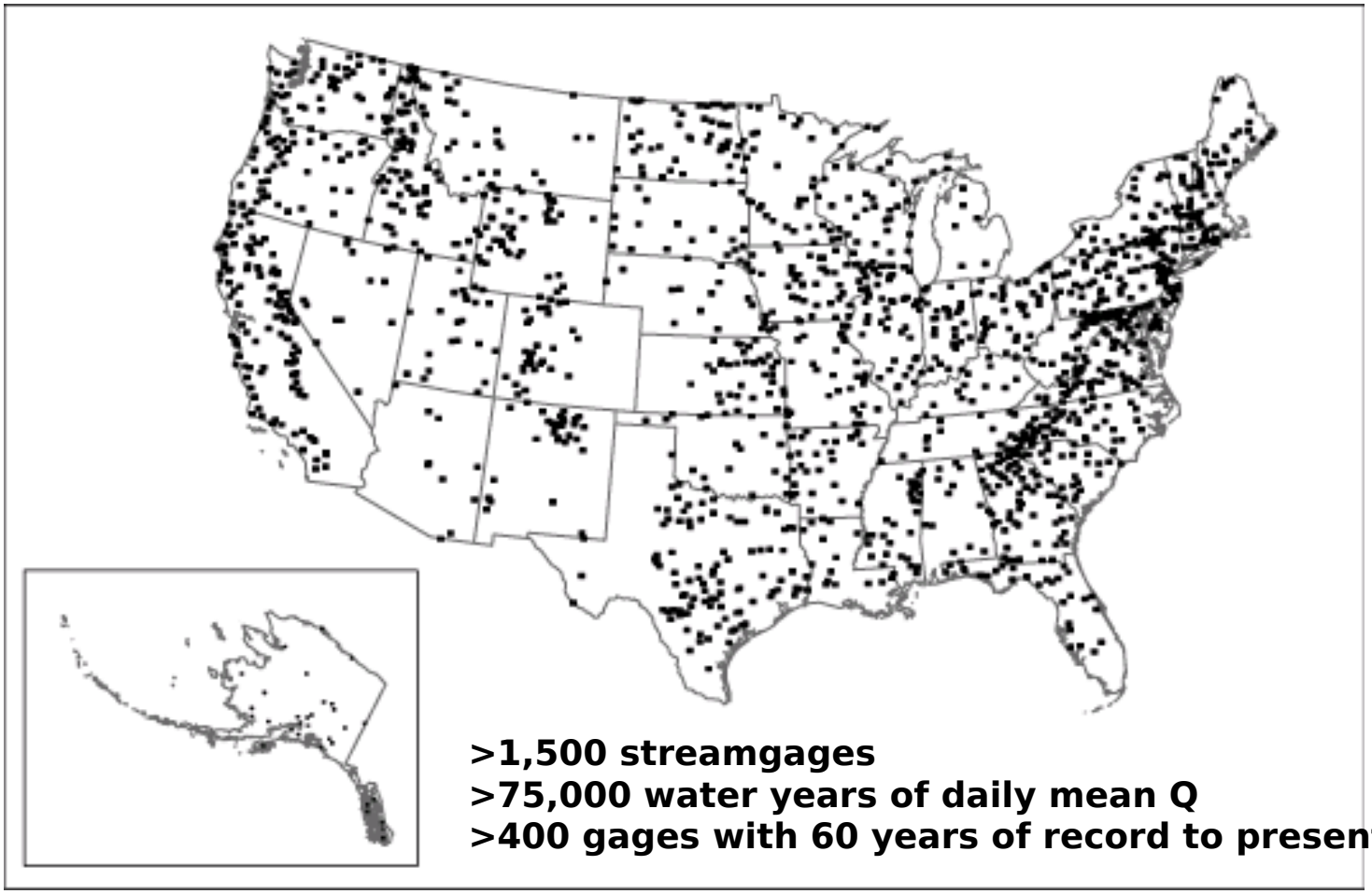
Hydro-Climatic Data Network (HCDN)



>1,500 streamgages
>75,000 water years of daily mean Q
>400 gages with 60 years of record to present

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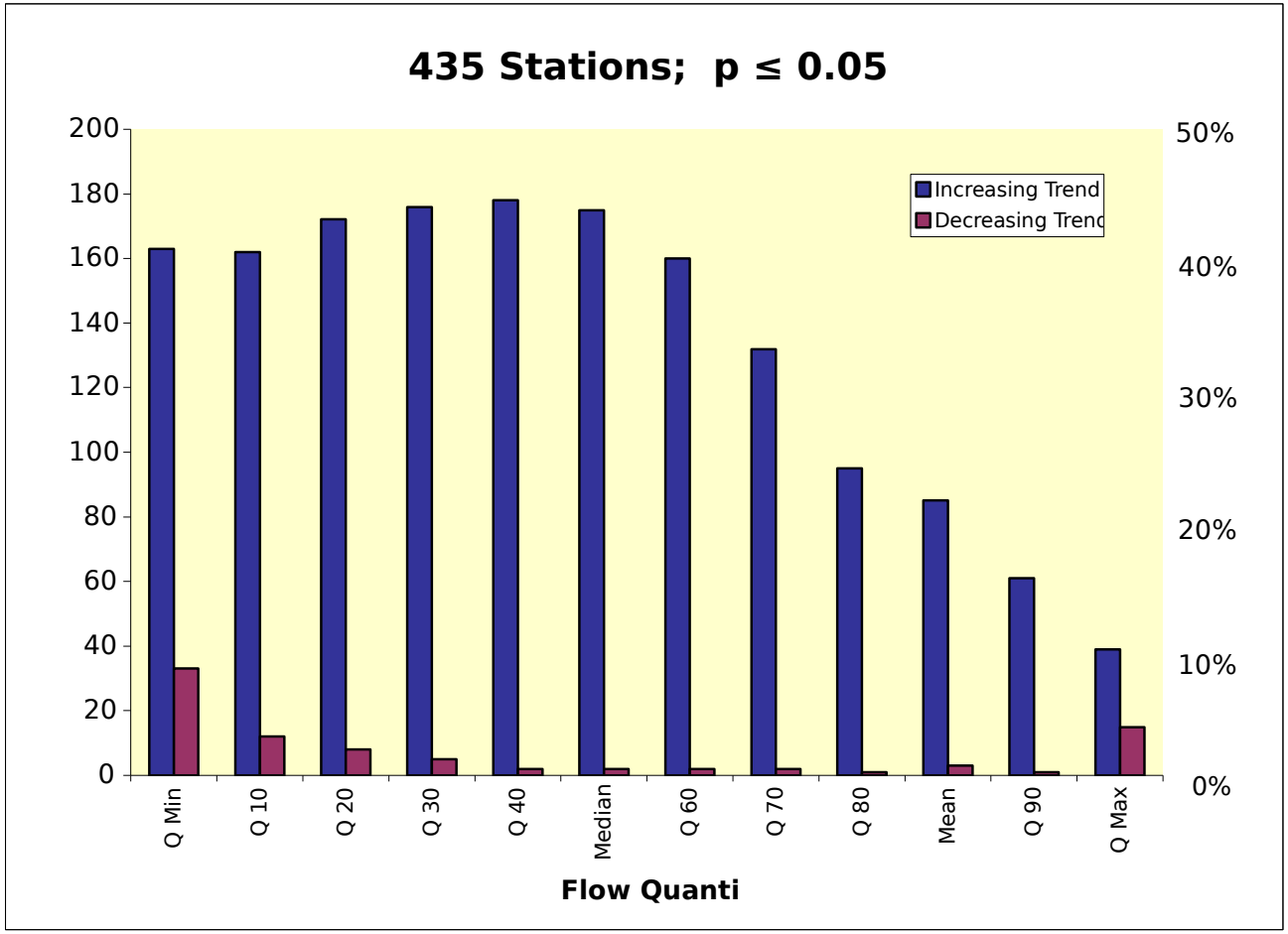
Source: Slack and Landwehr, 1992, USGS OFR 92-129

Trends in U.S. Streamflow, 1940-1999



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Source: Lins and Slack (2002) GRL; (2005) Phys. Geo

Regional Pattern of Trends

Percent of Stations Having Trends, by Water Resources Region, 1944-2003

	Q_{Min}	Q_{Med}	Q_{Max}
New England (23)	17↑		
Mid-Atlantic (75)	11↑		
S. Atlantic-Gulf (65)	37↓		
Great Lakes (20)	60↑	75↑	
Ohio (76)	57↑	37↑	
Tennessee (12)	16↑	25↑	
Upper Miss (65)	82↑	82↑	11↓
Lower Miss (2)	50↑		
Souris-Red-Rainy (8)	63↑	75↑	13↑
Missouri (36)	50↑	36↑	14↓
Ark-Red-White (15)	33↑	13↑	
Texas-Gulf (21)	62↑	76↑	13↑ 10↓
Rio Grande (0)			
Upper Colorado (7)	14↓		
Lower Colorado (2)	50↑		
Great Basin (11)			
Pacific Northwest (55)	45↓		11↓
California (30)	17↓		

Note: Blank cell indicates less than 10 percent of stations had trends.

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Source: Lins and Slack (2005) Phys. Geo

Shifts in Timing of Q_{max} and Q_{min} by decade, 1940-1999

Monthly Variation in the Number of Annual

Maximum (top)

Minimum (bottom)

Discharges by Decade, 1940-99

Explanation

Mean of period (horizontal line)

1940-49 (left-most vertical bar)

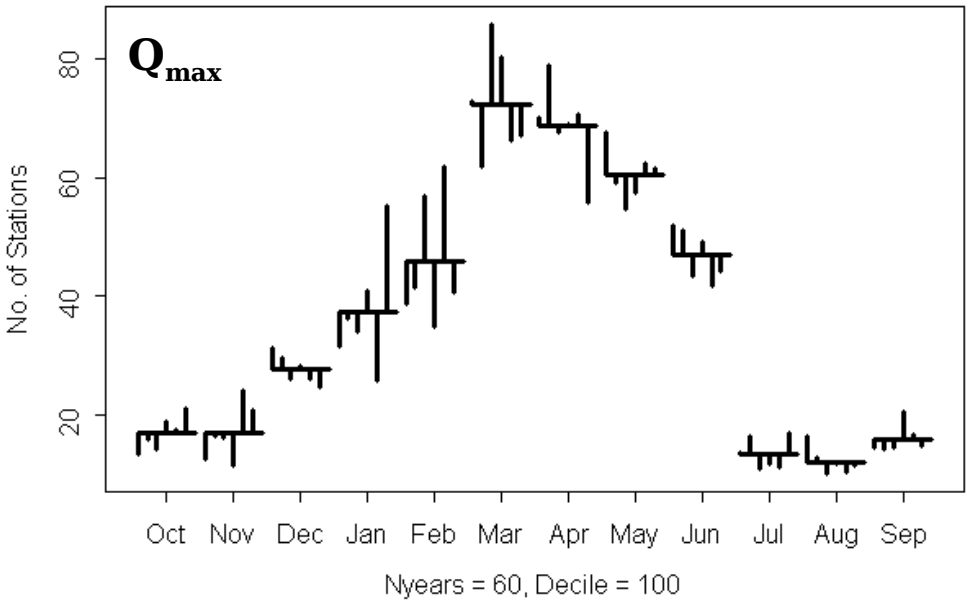
1950-59

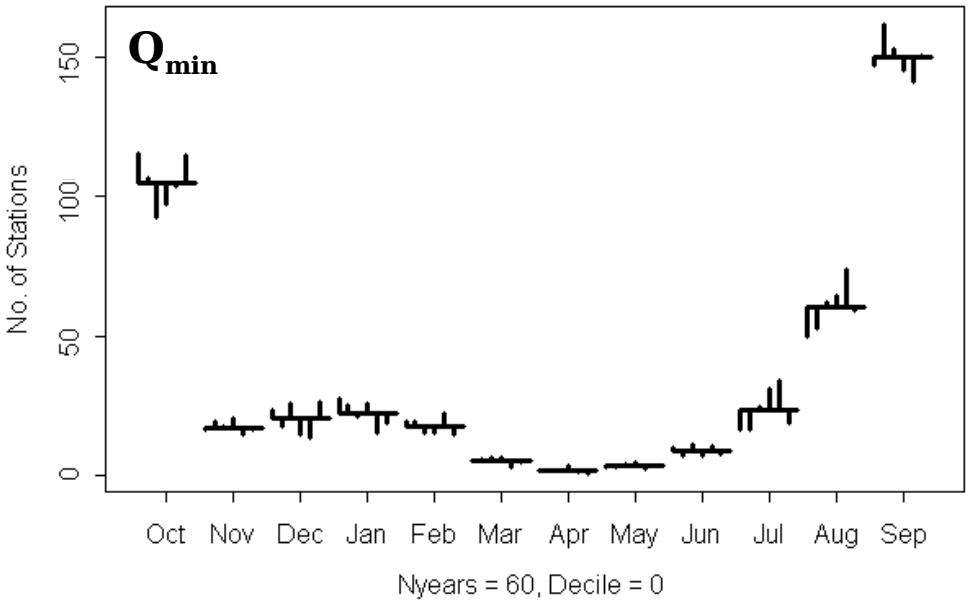
1960-69

1970-79

1980-89

1990-99 (right-most vertical bar)





Source: Lins and Slack (2005) Phys. Ge

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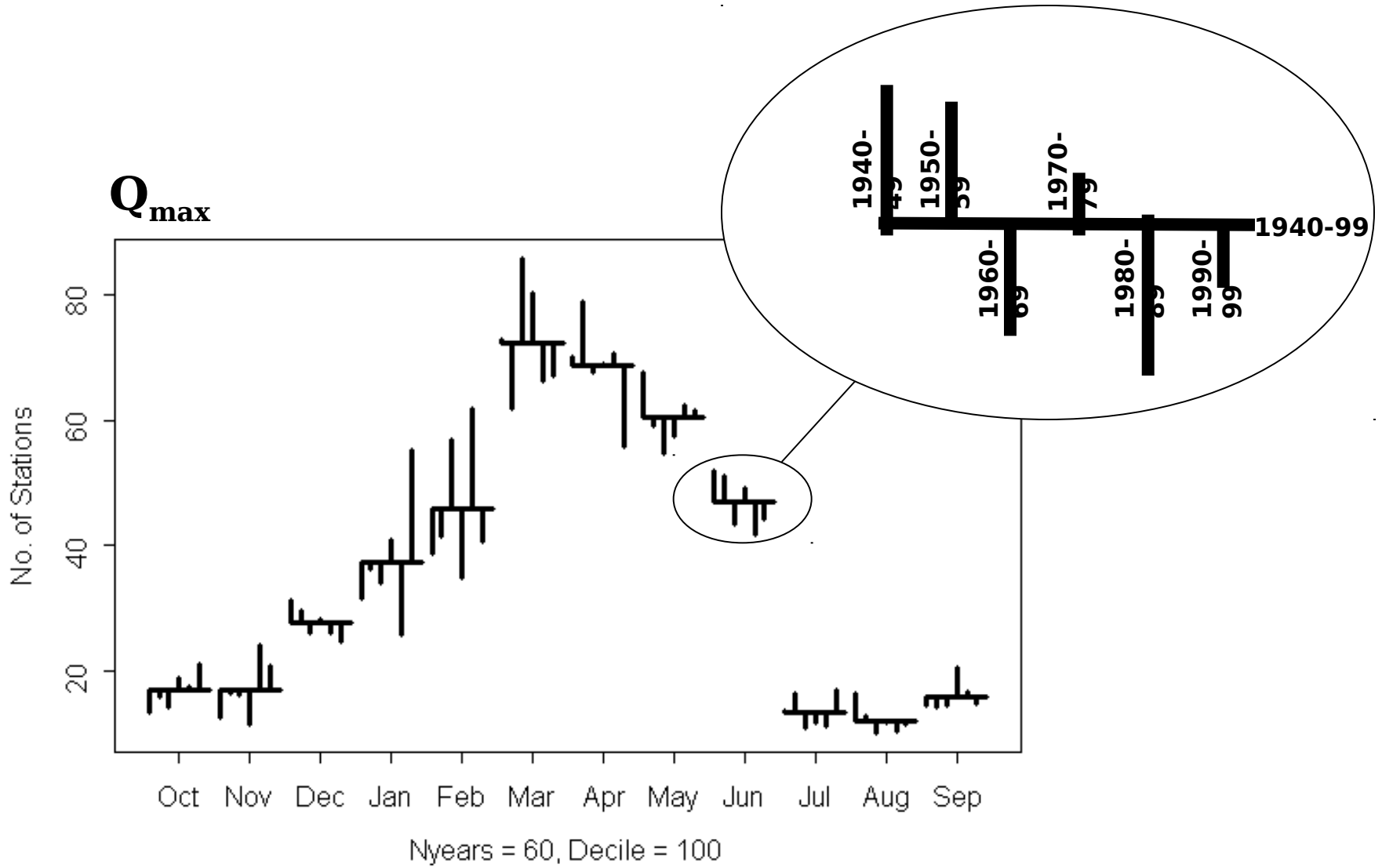
Seasonal Subseries Plot



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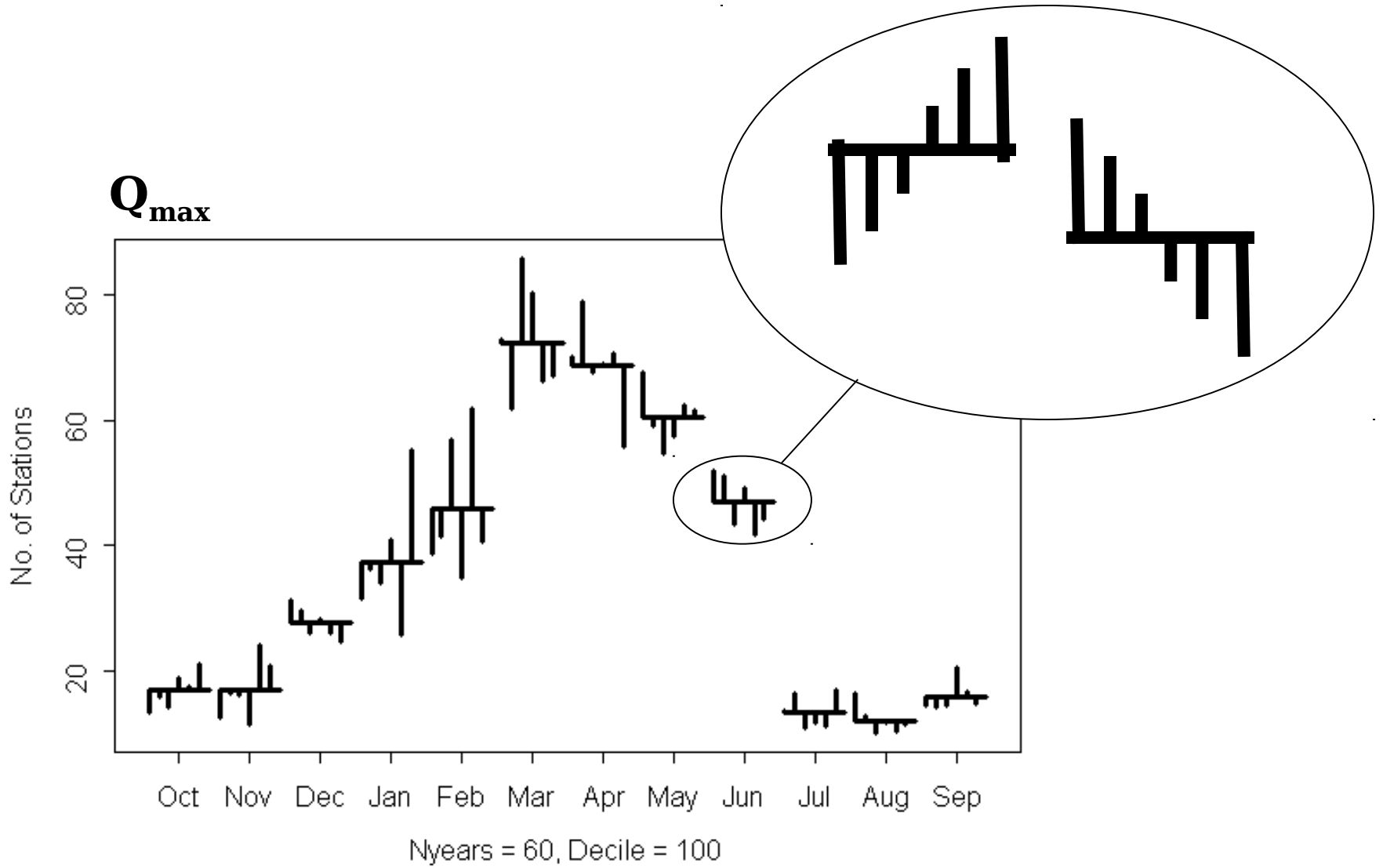

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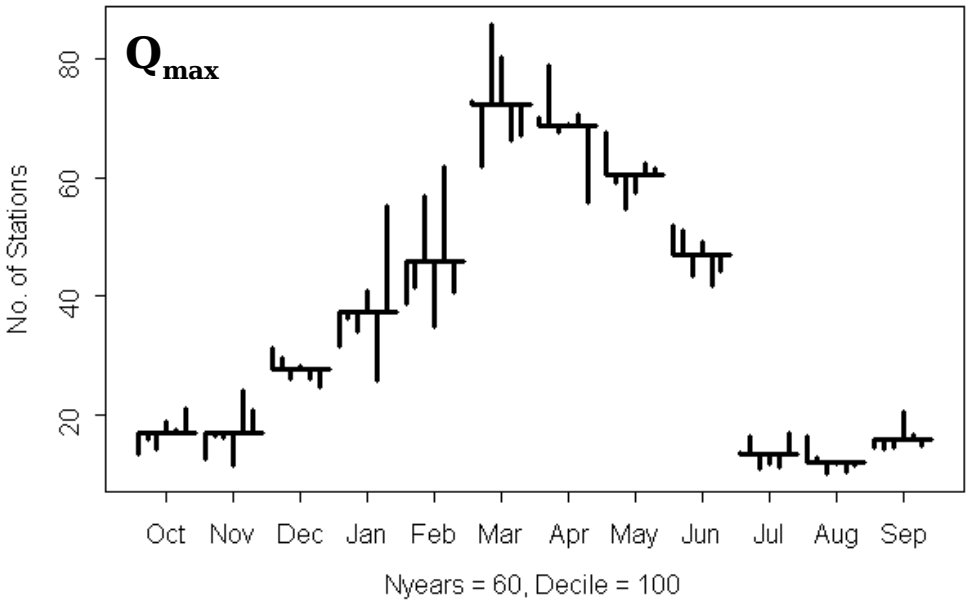

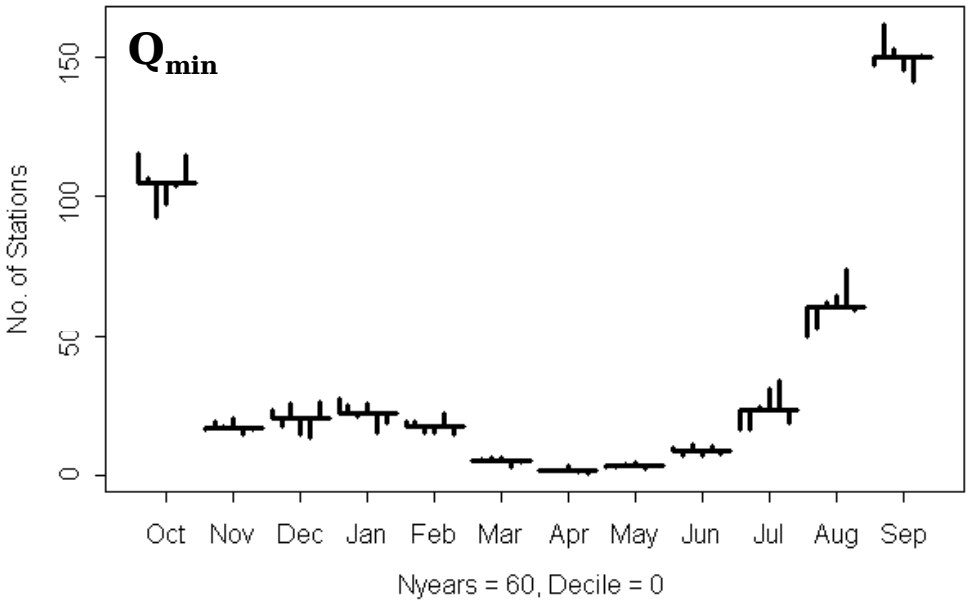

Source: Lins and Slack (2005) Phys. Ge

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gional Flow Seasonality and Monthly-Scale Timing Shi

WATER RESOURCE REGION	NUMBER OF STATIONS	MONTH(S) OF MOST FREQUENT OCCURRENCE, AND TIMING SHIFTS FOR		
		Q_0	Q_{50}	Q_{100}
New England	19	*Sep* (NC)	*Dec* (NC)	*Apr* (NC)
Mid-Atlantic	49	*Sep* (NC)	*Jan* (NC)	*Mar* (NC)
South Atlantic-Gulf	62	*Sep* (NC)	*May* (NC)	*Mar* (NC)
Great Lakes	15	*Sep* (NC)	*Nov-Dec* (NC)	*Apr* (NC)
Ohio Valley	45	*Sep* (NC)	*May-Jun* (NC)	*Mar* (NC)
Tennessee	10	*Sep* (NC)	*May* (NC)	*Mar* (NC)
Upper Mssissippi	57	*Sep* (NC)	*Nov* (NC)	*Mar* (NC)
Lower Mississippi	5	*Sep* (NC)	*May* (NC)	*Mar* (NC)
Souris-Red-Rainy	6	*Feb* (NC)	*Nov* (NC)	*Apr* (NC)
Missouri	31	*Sep* (NC)	*Nov* (NC)	*Jun* (NC)
Arkansas-White-Red	17	*Sep* (NC)	*Jan* (NC)	*May* (NC)
Texas-Gulf	21	*Sep* (NC)	*Jan-Mar-Apr* (NC)	*May* (NC)
Rio Grande	7	*Sep* (NC)	*Oct* (NC)	*May* (NC)
Upper Colorado	3	*Feb* (NC)	*Oct* (NC)	*May* (NC)
Lower Colorado	3	*Jul* (NC)	*Nov* (NC)	*Mar* (NC)
Great Basin	8	*Sep* (NC)	*Jan-Feb* (NC)	*May* (NC)
Pacific Northwest	52	*Sep* (NC)	*Nov* (NC)	*May* (NC)
California	24	*Sep-Oct* (NC)	*Jun* (NC)	*Feb* (NC)
All Regions (total)	434	*Sep* (NC)	*Dec* (NC)	*Mar* (NC)

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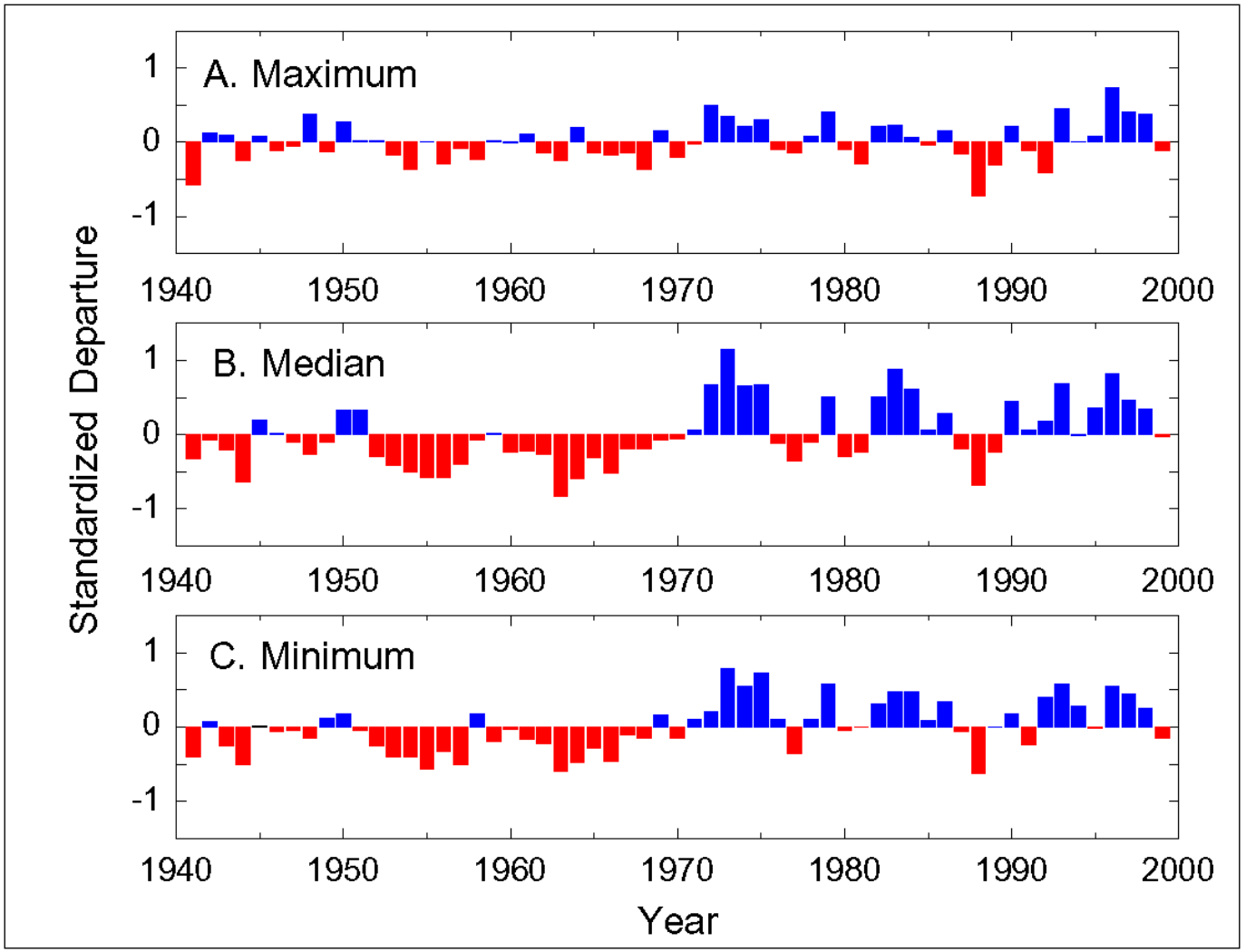
Source: Lins and Slack (2005) Phys. Geog.

Nationwide StreamflowTrends

Mean Standardized Departures for 400 Stations, 1941-99



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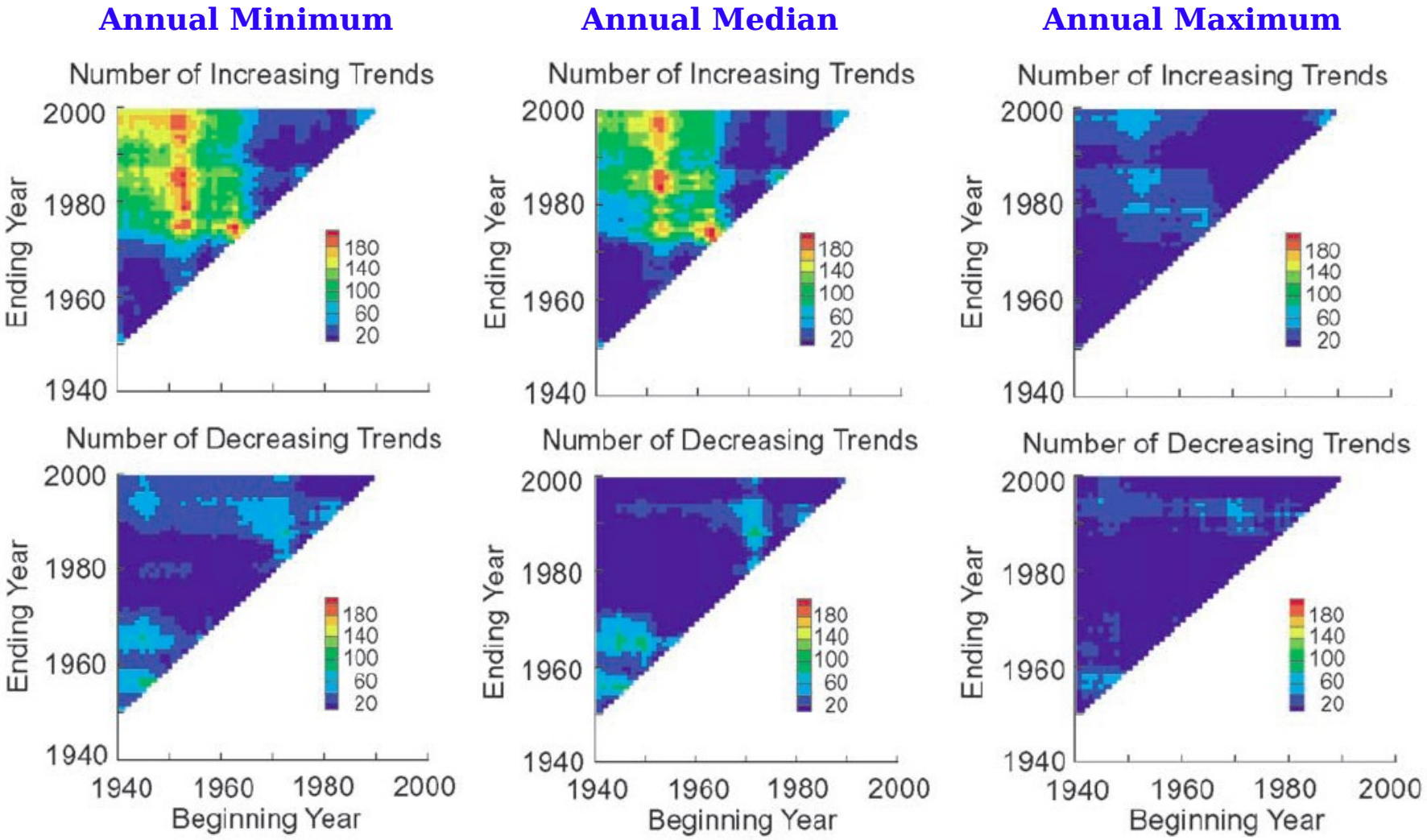
Source: McCabe and Wolock (2002) GR

s by Beginning and Ending Dates for 400 Stations, 19



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Source: McCabe and Wolock (2002) GR

Are Floods Increasing?

- Data in USGS Peak Flow File for 23,526 sites
- Of these, 2,515 had NWS identified flood stage
- Of these, 825 had complete records for 1941-2000
- Of these, 247 did not have qualification codes associated with stage datum, backwater, dam failure, regulation, diversion, ice-jam, urbanization, mining, agricultural changes, or channelization
- Of these, 200 were unregulated, 47 regulated

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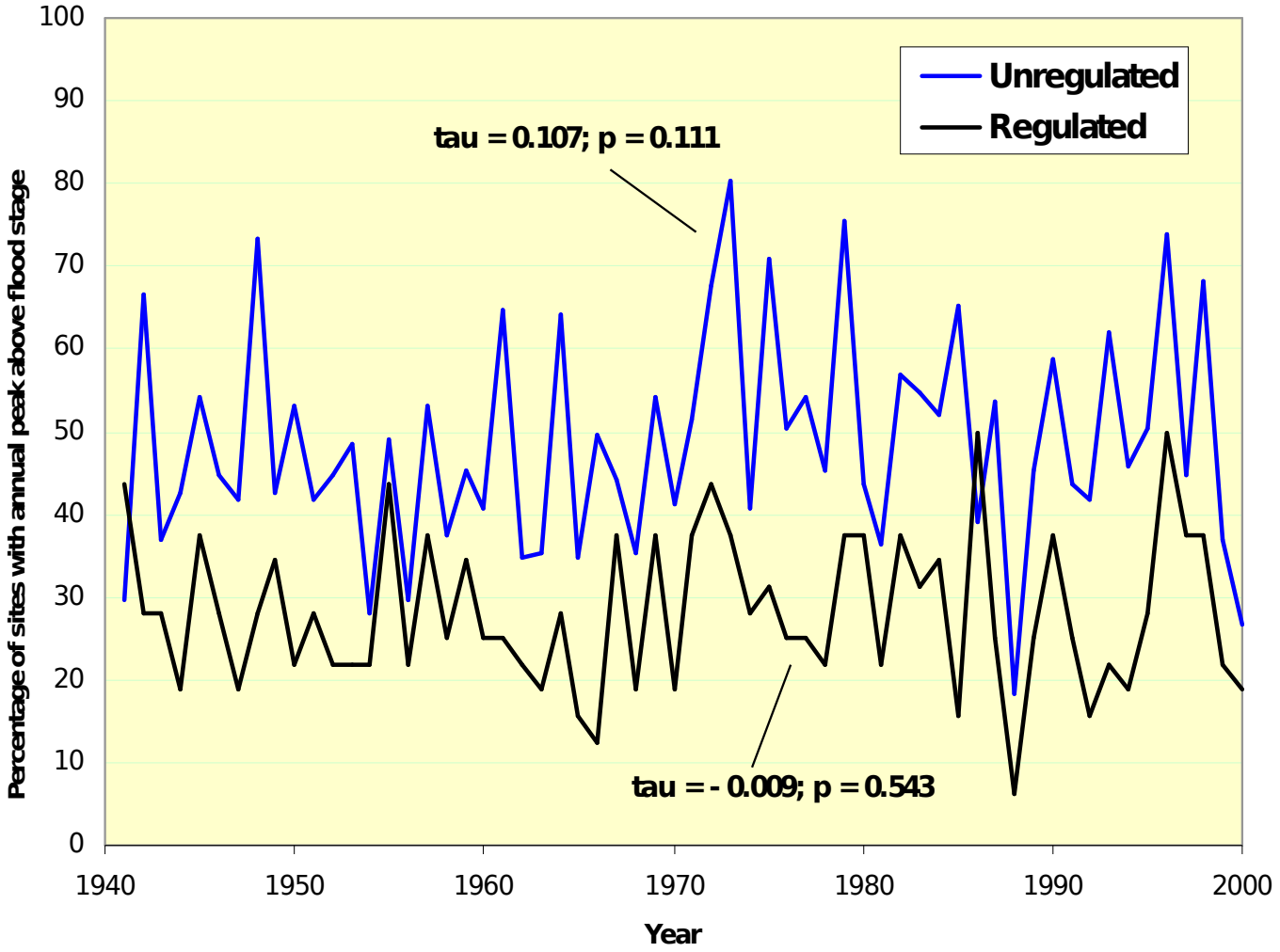
Percent of Streamgages with Annual Peak Above Flood Stage, 1941-2000



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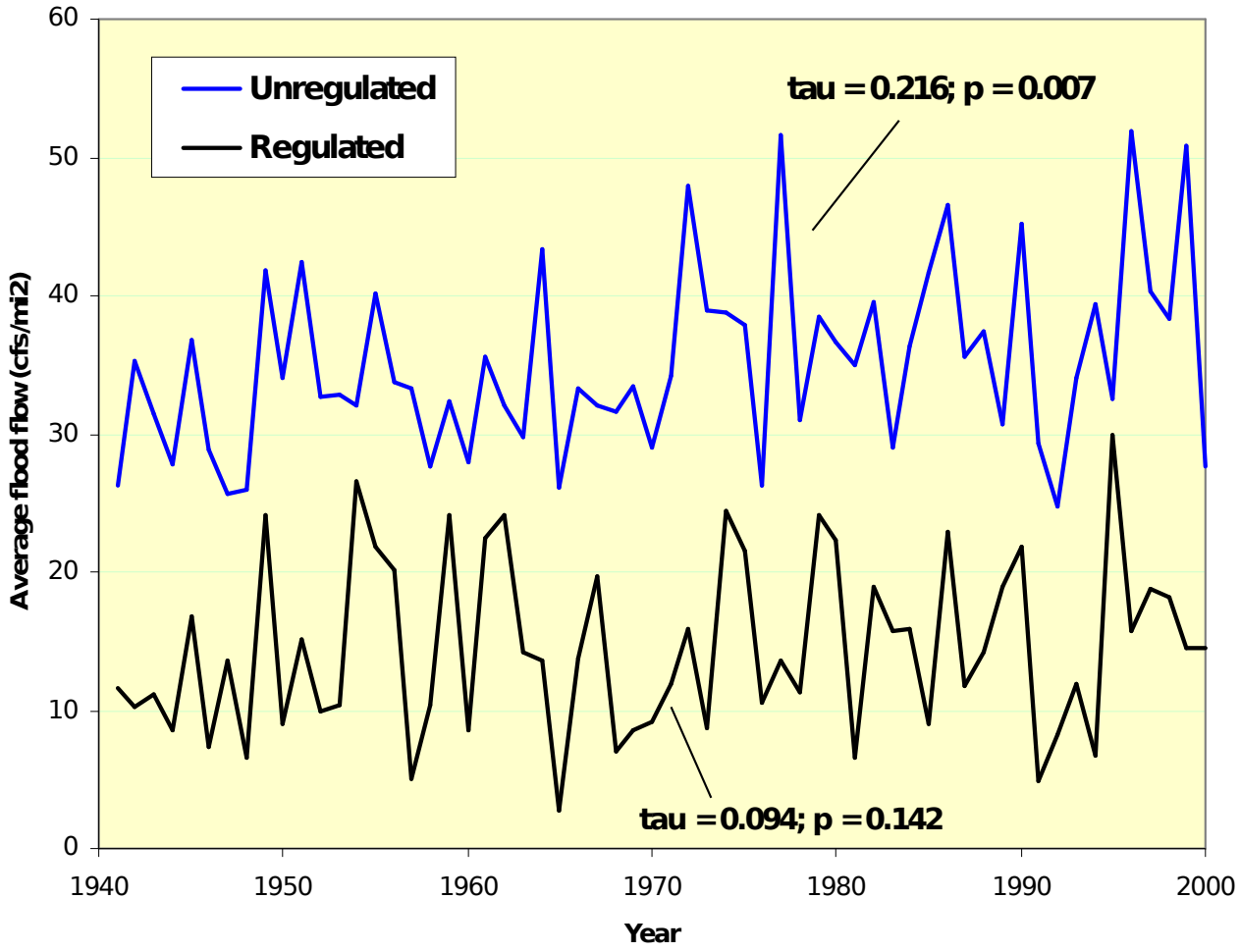
247 streamgages: 200 unregulated, 47 regulated

Average Flood Flow, 1941-2000



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Summary of Observed Streamflow Trends

- Streamflow increased in the U.S. between 1940 and 1999
- 40-45% of streamgages had increases in Q_{min} to Q_{60} flow while 10% had increases in Q_{100} flow
- Increases occurred as a step-trend around 1970
- Increases observed in nearly all regions of U.S., except Upper Colorado, Great Basin, PNW, and California
- No monthly-scale shifts in the timing of Q_{min}, Q_{med}, and Q_{max}
- No trend observed in frequency of floods, although an increase was observed in the volume of flood flows at unregulated sites

USGS